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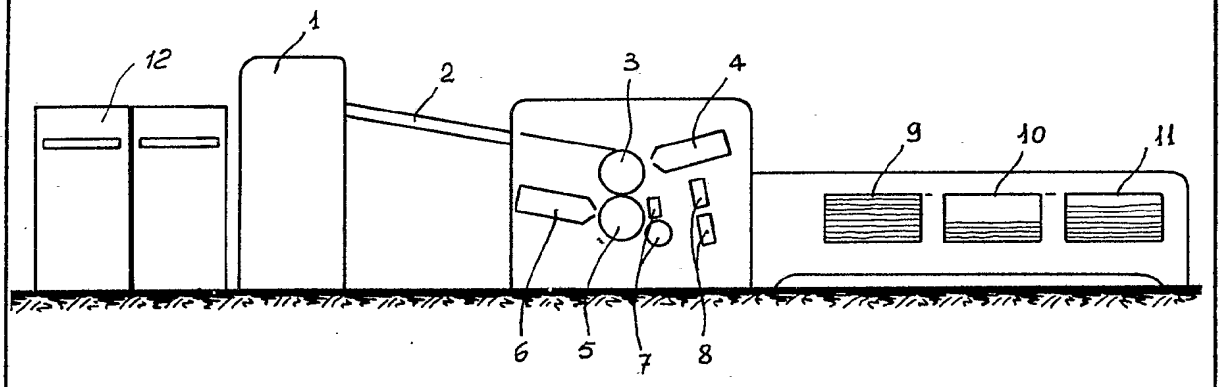
(71) Applicant Enrico Bianchi, 9 Via Borgogna, Milano, Italy
(72) Inventor Enrico Bianchi
(74) Agent Matthews, Haddan & Co.

(54) A Machine for Automatically Controlling the Quality on Freshly Printed Banknotes and Valuable Documents

(57) The machine comprises a control head pair 4, 6, e.g. photoelectric heads, being effective to examine single sheets (bank notes) at high speed e.g. held on a suction smoother cylinders 3, 5. The head pair scans the front and rear surfaces of the sheet along a plurality of paths. The signal is compared with a signal representing a sample or reference sheet. By this comparison any defect, e.g. in ink tones, generates a reject signal to actuate a downstream printing mechanism 7 which impresses a suitable cancellation mark on the defective note. Further devices 8 detect faults in the filigree pattern. The sheets are ultimately delivered to box 9, 10 or 11 according to the defects sensed.

Fig. 1



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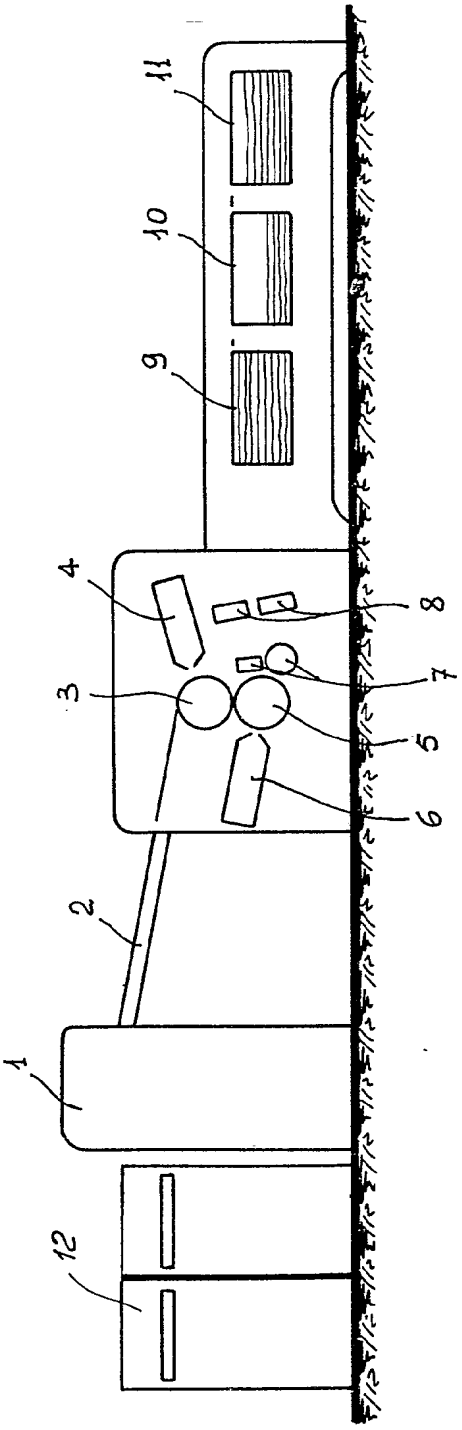


Fig. 1

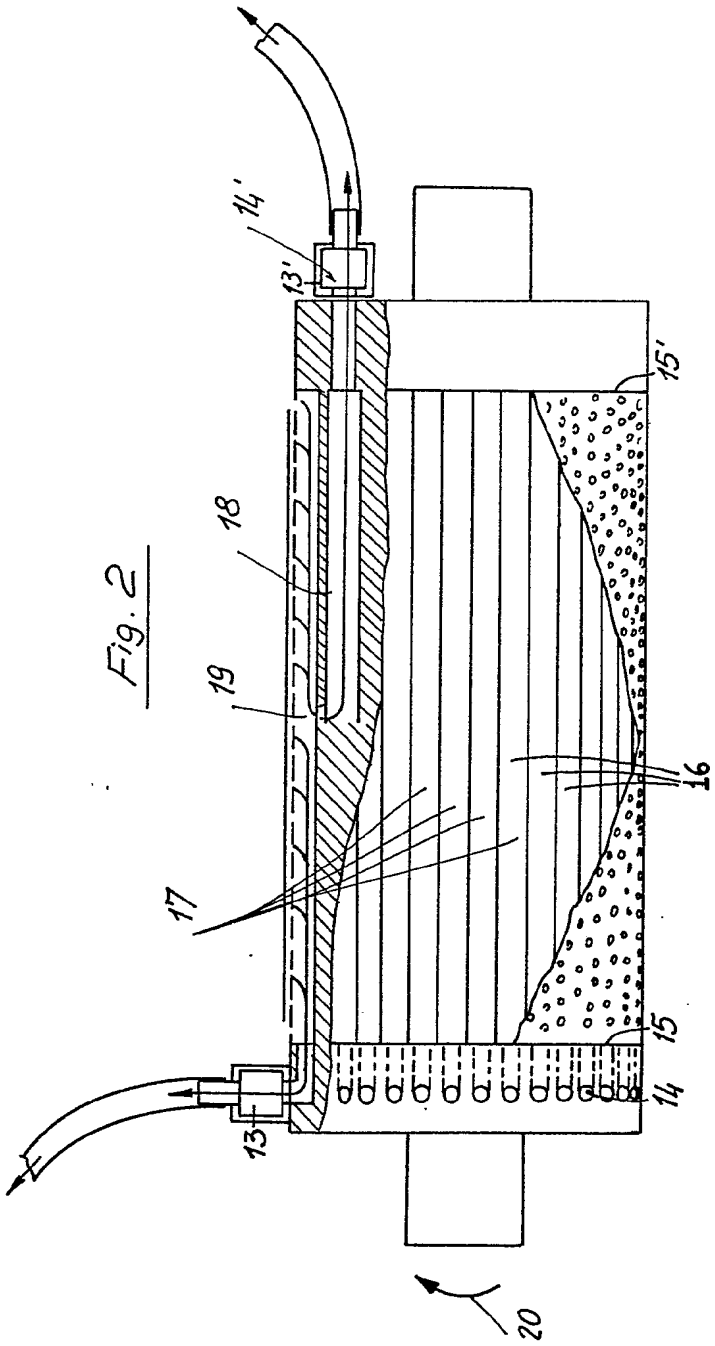
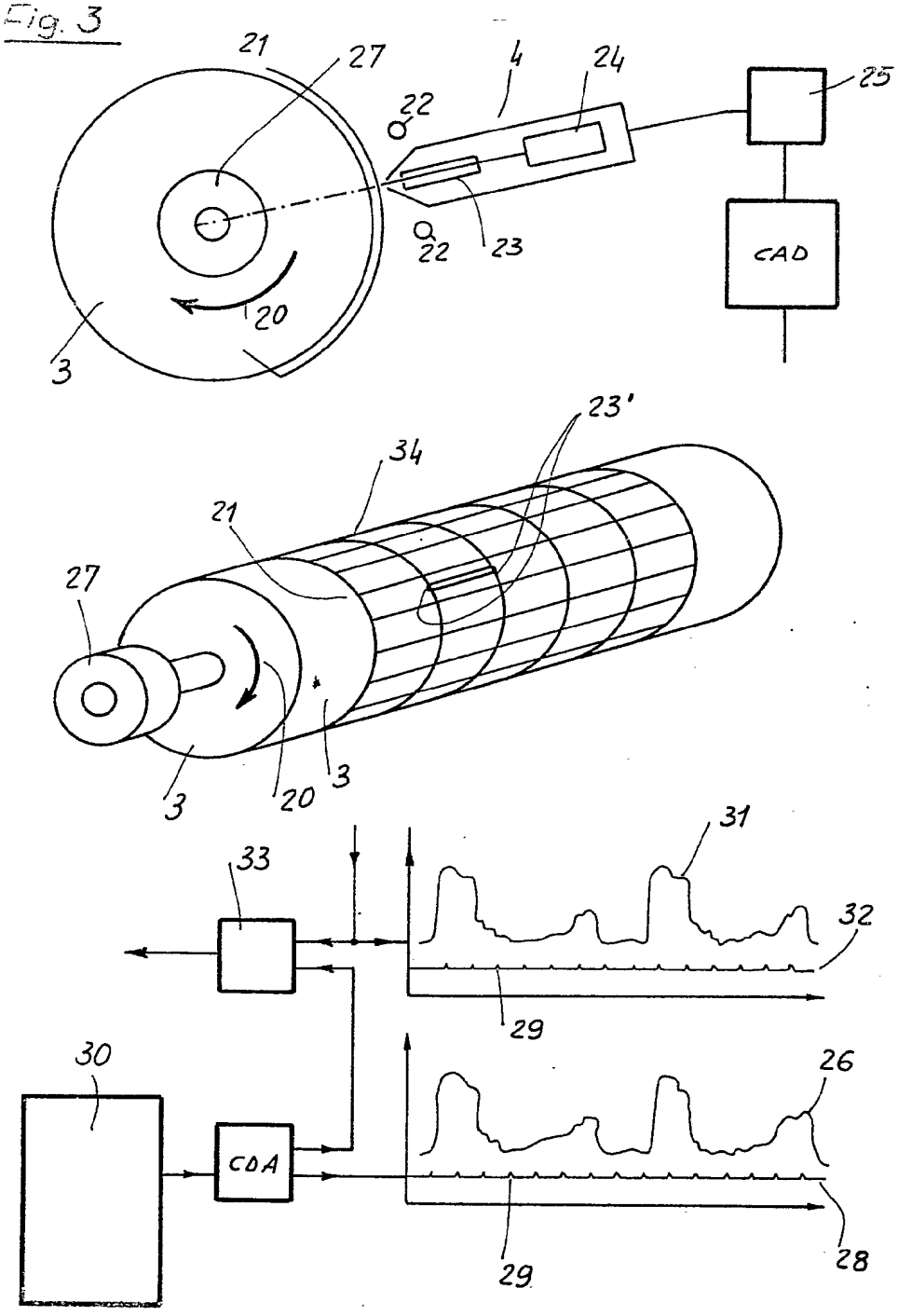


Fig. 2

Fig. 3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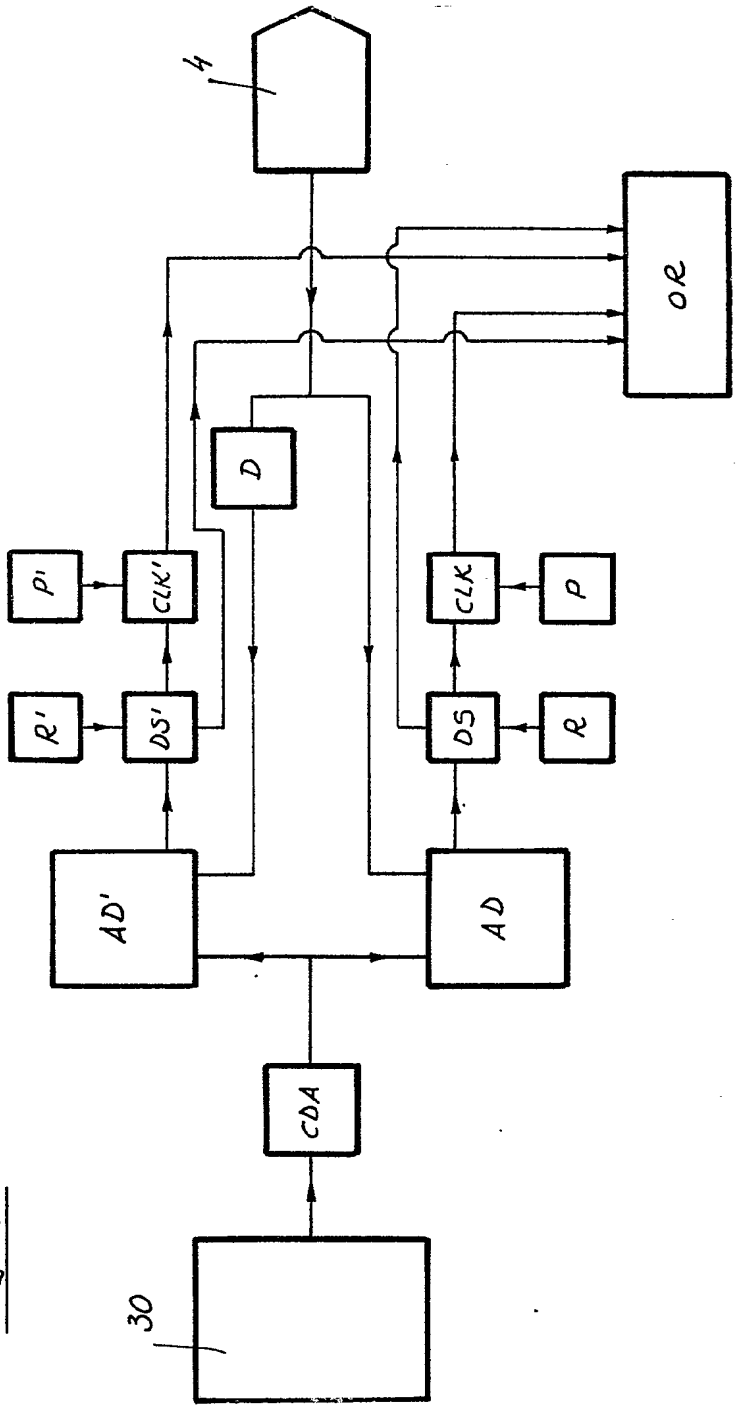

Fig. 4

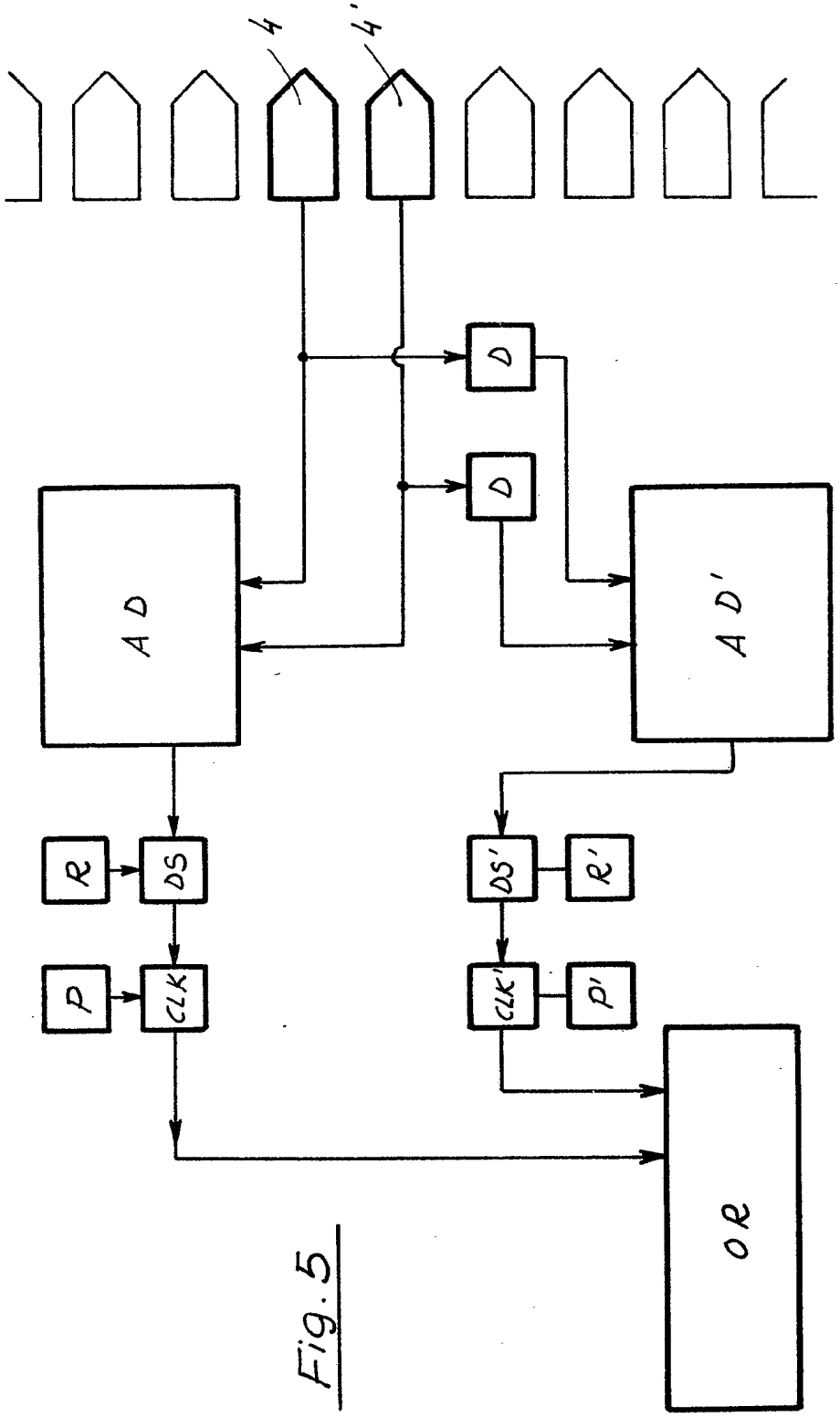

Fig. 5

SPECIFICATION

A Machine For Automatically Controlling the Quality on Freshly Printed Banknotes and Value Documents

The present invention relates to a machine effective to automatically carry out the quality control on freshly printed banknotes and value documents.

As it is known in the making process of banknotes and other value documents such as cheques, security documents, and so on, an important part of the cost is due to the controls which have to be carried out in order to obtain a perfect product. For "perfect product" is meant a banknote set provided not only with perfect printing characteristics, but also with minimum offset from an ideal model.

In fact the characteristics of a banknote are such as to make difficult the reproduction by forgers. Accordingly the emitting institute has to produce perfect banknotes provided with homogeneous characteristics, in order to be able of immediately detecting the presence of a false banknote in a set of valid banknotes, in the form of a banknote which deviates, even in a slight degree, from the standard. This is possible only at the expense of a high quality standard of the valid banknotes.

It is also known that the most important steps in the banknote making process consist of the printing of the lithographic (offset) sheet bottoms, of the printing of the chalcography (engraving) sheet figures, and of the subsequent numbering of the banknotes, still in sheet form, to which latter step follows the cutting operation of said sheets for forming banknote packs. These latter are then subjected to a final control and suitably packaged.

From the other hand, during the lithographic bottom and figure printing step, notwithstanding the perfection and automatism achieved in the making process, are produced a plurality of sheets (from 5 to 17%) thereon the single printed banknotes present defects which require the rejecting of said banknotes. If these sheets, provided with imperfect banknotes, were sent to the subsequent working steps, there would be obtained paks including many defective banknotes, and the final control cost for the replacement would be prohibitive.

In order to eliminate the aforesaid drawback, before numbering the single sheet banknotes, a manual control on the quality of said sheets is carried out in order to remove from the making process the defective banknotes.

Nowadays, the quality control of the sheets is carried out by operators examining said sheets, by visually inspecting under perfect illumination conditions such as to evidenziate the presence of the possible defects even if very small. The sheet under examination is accurately inspected firstly on a face thereof and then on the opposed face.

That same operator turns over the sheet under examination, and piles up said sheets together the sheets evaluated as suitable for the subsequent operations, provided that sheet be perfect, or the operator marks the defective banknotes and piles up said sheet together with the sheets to be discarded.

A first drawback of said operating way is due to the slowness of the operative process carried out by the human eye, which has to subsequently observe the several parts of the sheet under examination, and to the slowness of the mechanical handling process of said sheets.

Another drawback consists of the variation in the time of the operator attention, which may be compensated for only by intercalating in the work frequent rest cycles and/or by slackening the inspection process speed.

The poor productivity or yield of the thus organized control step, requires furthermore a very great number of operators in order to carry out the control work on the product of a printing shop, even of small size. This fact, in turn, involves a distribution of the sheets to many persons, with a consequent very fatiguing control work at the delivery and at the giving back.

Further drawbacks of the aforesaid operating process consist of the high cost of the labor for carrying out such types of control, which cost is subjected to progressive increases and of the difficulty of finding operators having the necessary requirements and able of bearing said psychologically tedious work.

It should moreover be pointed out the possibility, never to be absolutely excluded, of possible tamperings or violations of the material under working, due to the continuous type of handling of the printed sheets by the plurality of operators and to the lackness of homogeneity of the work carried out by said operators.

For concluding these detail considerations, it is possible to observe that the control work is the only step of the production which, differently from the others, has not been yet completely automatized.

In fact, nowadays are manually marked only the banknotes affected by the observed defect. By this procedure, the sheet, even if separated by the pack of those sheets accepted as good, is processed in such a way as to discard the defective banknotes, permitting however the recovery of the "good" banknotes. The purpose of this manual marking of all of the defective banknotes is to permit, during the subsequent working step, an easy detection of the banknotes to be discarded both by the operator and by the automatisms.

The machine effective to provide the automatical control of quality on freshly printed banknotes and value documents according to the present invention eliminates, on the contrary, the aforesaid drawbacks since it is able of completely automatizing the sole manual step of the working and production process.

The instant system for automatically controlling the quality on freshly printed banknotes and value documents has been invented in order to overcome the aforesaid

drawbacks, that is mainly for completely automatizing the sole manual step of the banknote and other value document making process, thereby making the control work speed greater than the manual work speed while preserving, or improving, the quality thereof.

The instant machine for automatically controlling the quality on banknotes and value documents may be used for a printing carried out on sheets containing banknotes arrays, aligned in rows and columns parallel to the sheet edge, as they are conventionally printed in the printing shops of the emitting Institutes using the sheet printing.

That same machine, furthermore, is effective to operate, with the same performance, also in printing shops using the bobbin printing system. In this case, in particular, will be used only the part relating to the selecting heads, the obliterating machine and all of the inherent electronics, the mechanical portion being not necessary in that it is replaced by a portion of the conveying assembly which is present in the bobbin printing machines of known characteristics. These machines, in fact, are particularly suitable for this purpose because they inherently solve any transport problems, with a perfect abutting and adhesion of the bobbins and hence of the banknotes, under the quality controlling heads.

More particularly, the machine for automatically controlling the quality on banknotes and value documents according to the present invention consists of a control head pair, said control heads being sequentially located, which examinate the printing quality respectively on the recto and verso of the single sheets.

Downwardly of said control head pair, is located a printing machine which, at the passing of the several banknotes, marks a detecting mark only on the defective banknotes, acting as a consequence of the storing of the possible defects detected by the aforesaid head pairs.

Then the sheets to be controlled pass through further apparatuses or devices, effective to verify the abutting presence of the filigrees, and are then conveyed within suitable differentiated boxes.

These and other characteristics, of functional and constuctional nature of the machine effective to carry out the automatic control of the quality on freshly printed banknotes and value documents according to the present invention will become more apparent from the several figures of the accompanying drawings, in which:

Figure 1 is a schematic side view of the instant machine;

Figure 2 is a partially cross-sectioned view illustrating one of the cylinders for conveying the sheets under the control heads;

Figure 3 illustrates the functional diagram of the those same control heads;

Figure 4 illustrates a block diagram of the apparatus or device for processing the signal provided by the photometric head, and

Figure 5 is a block diagram in which signals from a plurality of photometric heads are processed.

Referring to the aforesaid figures, the machine for automatically controlling the quality on freshly printed banknotes and value documents according to the present invention consists of a loading zone (1), provided with a feeder, comprising devices of known type as conventionally used in the machines for printing value documents or banknotes. In this way it is possible not only to suitably examine the sheets at a current speed of about 8,000 sheets per hour, but it is also possible to obtain the same precision from the starting to the subsequent conveying operations.

Downwardly from the aforesaid loading zone is located a starting path (2) comprising a squaring device similar to the squaring devices conventionally used in the sheet printing machines.

Said path supplies a cylinder (3) for conveying the sheets under the recto quality inspection head, the task thereof being that of brinking adherent to the surface thereof the sheet under examination, in order to present the face remaining at the outside to said control head.

However the sheet has to remain wrapped on the cylinder, presenting in a perfect abutment with respect to the observation axis of the optical head.

Obviously this perfect abutting or registering has to be obtained according to two directions: the direction of the cylinder rotation, or sheet advancing direction, and the direction of the cylinder generatrix, perpendicular to the movement direction. The "registering or abutting" related to the first direction will be called longitudinal abutting and that related to the second direction will consequently called transversal abutting.

Since the system for automatically controlling the quality on freshly printed banknotes and value documents has to process sheets thereon are printed banknotes, that is banknotes printed also by the chalcographic process (and in this process the sheet is strongly compressed), at the operation end the sheet plane is frequently curved or bulged and the flattening thereof is prevented, even if said sheet is pressed against the cylinder.

The function of the members of this latter is accordingly also that of causing the sheet to adhere to the cylinder surface in a perfect way. In order to meet these requirements, while carrying out the transporting fuctions, the cylinder is realized as illustrated in Figure 2.

In this figure, the cylinder is shown sectioned at the top, in order to illustrate the inner structure, while at the bottom is shown the outside structure.

It should be pointed out that in the aforesaid view is not shown the sheet gripping portion. This gripping device is realized by pliers, of that same known type used for the gripping in perfect abutting of the sheets on the printing machines.

Said pliers, in fact, assure a perfect longitudinal abutting or registering of the sheet on the cylinder and preserve the perfect transversal registering provided by the side square present on the starting paths (2).

The device which allows for the sheet, even if bulged, to adhere and locate in a flat condition on the aforesaid cylinder, consists essentially by two sucking devices (13, 13') which slide practically at contact with the end portions of the cylinder, said portions being smooth and ground, in such a way as to obtain the vacuum thickness. It is unimportant that the sucking device be located on the surface or on the bases of the transport cylinder, as shown, respectively, at (13 and 13').

At the bands thereon slide said two sucking devices or boxes are located the hole paths (14, 14') which admit the vacuum to the cylinder central band indicated by the limits (15, 15'). Between said limits, the cylinder surface is perforated by a hole matrix, said holes having a diameter of 3—5 mm and being located at a distance of about 10 mm from one another. The underlaying volume (16) is hollow and conducts the vacuum taken from the aforesaid sucking boxes or devices. The sectors (17) are located within this sucking cavity in order to delimitate the sucked zone only at the holes which, due to the cylinder rotation, pass under the sacking box.

This solution, particularly illustrated in the left portion of Figure 2, causes a sucking effect firstly on the sheet sides or edges and then on the center thereof. This sucking type is suitable for sheets of high substance. In the case of low substance, on the contrary, it is more suitable to start the vacuum from the center, and to this end is better suitable the device illustrated in the right portion of that same figure.

Under the sucking spaces (16) extends a vacuum duct (18) which conducts the sucking vacuum through the holes (19) at the center of said spaces. The conventional devices for alternating or switching the two sucking types have been not shown.

The arrow (20) indicated the rotation direction of the cylinder. If the sheet were present in the pliers, the gripping edge would be concealed in the invisible portion of the drawing, since it would be located at the rear. The observer would see a portion adhering by suction at the zone corresponding to the meridian lines thereon are located the sucking boxes. The free portion, downwardly extending, would be still near to the cylinder, but not perfectly adhering thereto, and, on the contrary, it would fly about said cylinder and away therefrom. During the rotation also this portion which progressively approaches the generatrices included between the two sucking boxes, is sucked and accordingly deposed and spread out.

It is important, and this constitutes a feature of the present invention, that the vacuum be progressively applied to the sheet for permitting to said sheet to spread out and progressively absorb the bulge possibly present therein.

The data relating to the hole matrix and to the spacing of the spacer elements (17) depends on the substance of the treated paper and the printing process thereto said paper has been subjected.

Said data are adapted, in the single cases, by means of perforated liners suitable for the material of each printing unit.

In order to better understand the following description of the heads for controlling the quality on freshly printed banknotes and value documents according to the present invention, it is deemed necessary to preliminarily describe the characteristics of the selected material (sheets) and the requirements imposed by the particular type of material which has to be processed.

The material to be controlled consists of printed sheets on the recto and verso thereof has been printed the banknote recto and verso image.

Said banknotes have a rectangular shape and are ordered by row (in the transversal direction of the sheet) and by columns (in the longitudinal direction of the sheet). Depending on the paper and banknote size, on a printed sheet may be located few or many banknotes (generally the number thereof being rarely smaller than 24 or greater than 80, while the column number, which frequently is 4, may raise to 5, 6 or to a greater value, the sheet size being also variable). In the machine for automatically controlling the quality on freshly printed banknotes and value documents according to the present invention, both the transport or conveying system which has been already described or which will be described in a more detailed way thereinafter, and the control elements herein described, are able of adapting both to the broadest size variation and to the number of the banknotes printed on the sheet, according to the user needs.

Furthermore a more strict requirement exists, relating to the quality controlling process, consisting in the searching of possible defects in the printing process. For "defect" it is meant an offset from an ideal model, and accordingly the defect amount or degree is measured by the amount of said offset.

The control carried out by the instant machine has a varying severity depending on the user selection, said user having the possibility of presetting the acceptability material threshold, depending on the needs.

Said control is practically carried out (see Figure 3) by feeding the sheet to be controlled (21) on the cylinder (3) rotating in the direction indicated by the arrow (20).

The portion which is progressively scanned out is illuminated by the lamps (22) which emit a light having a sun white colour in order to render the system particularly sensible to the tonalities in addition to the printing colour intensity.

The examination of the portion of the sheet to be controlled is carried out by a photometric module, formed by a light collimator (23), which scans a narrow strip (23') within the column (34) facing said module.

The light accepted by the collimator is transformed into an electric signal by means of photodiodes, phototransistors, arrays of said sensors or photomultipliers.

In the instant module, the light sensors are located in the zone (24).

The output signal of the sensor is supplied to the amplifier of known type (25) suitable for c.c. current signals, which prepares said signal for the subsequent processing.

The module which examines the sheet surface is thus able of producing, with the proceeding of the rotation of the sheet, a signal which has the characteristics of the signal of any other sheets devoid of defects passing on that same cylinder. This signal, represented by the curve (26) consists of a voltage versus time diagram.

However, a known type of encoder (27), rigid with the transport cylinder rotation axis, generates timing pulses, indicated in the diagram (28) with the peaks (29), which serve to transform the diagram (26) with a time abscissa into a metrical abscissa diagram.

The position of the peaks (29) provides a measurement of the position of the characteristics detected on the diagram (26) on the column (34) scanned in the sheet (21).

At said peaks (29) the signal is coded into a number measuring the height in Volts or Volt fractions, of the corresponding diagram (26). This value is then stored in a large size high speed integrated circuit digital store or memory (30). The reflection diagram of the column (34) is therefore transformed into a sequence of several value thousands which are indicative of the value of the reflection of the sample sheet in said column (34).

The store or memory, thus loaded by the digital values of the sheet reflection, constitutes a sample or electronic master of the sample sheet.

Since the column (34) has a width which is only a small fraction of the sheet width, the module (22, 23, 24, 25, 30) is repeated in many samples, the number thereof being that necessary for covering the overall sheet width.

Upon providing the electronic master of the sample sheet, the sheets to be controlled may be caused to pass through the machine. The aforesaid devices, for each sheet, provide diagrams (31, 32) which are analogous to the diagrams (26) and (28).

The electonic device (33) extracts from the store (30) the ideal diagram and carries out the comparing between said high ideal diagram and the real one related to the sheet currently present on the cylinder.

If the diagram (31) is identical to the diagram (26) in each of the modules preposed to the several columns in which is subdivided the sheet, then this latter is judged as perfect and delivered, as thereinbelow described, to the good-sheet collecting box.

On the contrary, the electronic system carries out a reading operation at that progressive peak (29) of the diagram (28) or (32) at which the discrepancy has been detected. The position of this error (or of an error sequence) is then imputable to a particular banknote on the sheet. This datum is then preserved in the memory of store, in order to provide the subsequent obliterating signal.

Obviously the described system operates on one surface of the sheet. An identical system permits to "masterize" or sample and inspect the opposed surface of the same sheet. Also this second system imputes the detected defect to one only banknote (or to a plurality of banknotes if the defect is extended), and combines the datum with that (or those) of the previously scanned surface. The position of the defective banknote is accordingly stored once, independently from the fact that the error is on one only surface or both the surfaces of the sheet.

It is important to consider some expedients which permit to accept as good sheets devoid of defects, but off of registering with the sheet profile or contour or conveyed by unperfect pliers and square. In fact a sheet may be gripped on the control cylinder without hitting against the gripping pliers bottoms. Alternatively, the distance between the printed edge or margin and the pliers side may slightly vary from sheet to sheet depending on the plate tension by which it has been printed in a chalcographic printing machine or due to other reasons. In all these cases, the signal diagram (31), even if, in the case of a perfect sheet, would be a precise copy of the master (26) signal diagram, would be compared with a phase shift which would cause homologous points of different reflecting power to be found, which would produce the rejecting of a good sheet.

In order to eliminate this drawback, is used an electronic type of synchronization between the peaks (29) of the encoder signals of the master (28) and the reading or read out signals (32). This synchronization is obtained by operating on the same channel of the photometer of each path.

Practically, at the arrival of the sheet is observed the white margin or edge; then arrives the margin or edge of the printed part and the signal greatly deviates from the value corresponding to the white. By means of known electronic devices, this sharp variation of the signal is used in order to cause the recovering from the stored or memorized master, of that diagram portion corresponding to the starting portion of the printed part.

This device is used on all of the photometric channels in which the sheet, inspection has been subdivided. However, if the transport mechanical system and the printed paper are of good quality, it is sufficient to use the synchronism system only for a fraction of the photometric channels, (for example a channel between three channels), and slave the synchronism or synchronization of the other two channels to the channel being provided with.

A sheet may be printed by the chalcographic method and it is possible that the sheet has been

subjected to a strong deforming pressure, thereby the profile of the printed portion, instead of having a rectangular shape, has a trapezoidal shape. In this case the two parallel sides of the trapezium are parallel to the transport cylinder generatrices, while the oblique sides are located as parallel onto the cylinder itself. With respect to an ideal rectangular master, this deviation from a perfect geometrical shape, carries, under the several control heads, different sheet zones which offer a signal being not identical to the masterized or sampled one.

This drawback is eliminated by the scanned area shape, which consists of elongated ractangular areas or regions. This expedient is advantageous in the sheet local-reflection measurement system in order to render said system insensible to the fluctuations of the side shifts or offsets caused by the variations of the trapezoidal shape of said sheet and variations of side registering.

The scanning slot may assume a shape different from the rectangular elongated shape: for example it may have a square or circular shape.

In this case said slot will move transversely with respect to the sheet, scanning said sheet by means of transversal alternating scannings.

In particular, it is unimportant that the apparent movement of said slot be obtained by a light flying spot alternatively illuminating the sheet at different zones, the reflected light of which is collected or picked up by the stationary sensor. Alternatively, in fact, the illumination may be fixed and even on the overall surface, while the scanning may be carried out by sequentially actuating the optical detectors, grouped in an array having an high packaging linear density (array of photosensible diodes).

In this case, the sensibility of the system to the variations of the side registering and trapezoidal shape of the sheet is resolved by synchronizing the transversal scanning power with the side edge printed on the sheet.

In this way, based on a principle analogous to that involved in the synchronization of the data in the longitudinal direction, is assured the comparing of the read out data with that related to homologous points of the stored master.

The characteristic itself of the scanned region, furthermore, render rather insensible the measurement of the local reflection carried out by the photometric heads to the variations tolerated by the position of the chalcographic and lithographic register.

Furthermore the quality control system provided by the instant machine permits to record as "master" sheet not only the aspect of a single sheet preselected to this end, but also the average or mean value of a plurality of sheets. In order to achieve this object, the electronic assembly or device is set, by means of a suitable control, in the "learning" position and the sheets are started along the system conveyor. The photometric signals collected on the recto and verso of the sheet are processed by means of a computer in order to obtain the desired average value.

A sheet may deviate for the ideal model due to several defect types, as thereinabove stated. Some of these defects may be believed to be concentrated, such as, for example, the spot defects, other defects, on the contrary, may be considered as diffused defects, such as the progressive variations of the lithographic bottom colours.

The illuminating device, jointly to the photometric head sensors and to the thereinabove described circuits (22, 23, 24, 25, 30) permits the system to achieve a printing variation detection sensibility able of detecting the 1.5% of the reflection maximum value on the white of the printed surface, both with respect to the saturation and the chroma of each banknote or portion thereof printed on the sheet.

In the case of point defects, (not diffused defects) the system is easily able of detecting spots having a 1 mm cross-section with a maximum contrast. In order to obtain the detection of point spots the system uses devices which will be described thereinafter.

The system is predisposed or set for selecting the sheets with a different severity degree, both with respect to the point defects, and with respect to the diffused ones, according to the user needs. This requirement is met by processing the signal of the photometric heads, which processing is carried out by the device (33) of figure (3) which is illustrated in a more detailed way in Figure 4.

The signal from the photometric head (4) is subdivided along two paths before being compared with the signal from the master memory. Along the shortest path, said signal is directly conveyed to the differential amplifier (AD) at which it is inputted through one of the two inputs. At the other input is supplied the signal picked up firstly in the numerical form by the digital store of the master (30) and then transformed into an analogic signal by the device (CDA).

Both the differential amplifier (AD) and the D/A converter (CDA) are of known type, and are formed by standard devices.

By means of the control (R) located on the operator control panel, one may adjust the rejecting threshold as measured by the discriminator (DS) thereby rendering the control more or less sensible to the differences of the sheet local intensity with respect to the master. If the measured difference exceeds the predetermined threshold value, is generated the rejecting signal, which is sent to the circuit (OR).

The signal from the photometric head (4) is also sent to the differentiating circuit (D) which transforms the signal of the photometric heads in such a way as to enhance the sharp variations of said signal, even if the amount of this variation is small and would be accepted by the subsequent comparing by the circuit (AD').

In a manner analogous to that of the circuit (AD), this latter receives the differentiated signal,

from one side, and, from the other side, the signal of the master (30) transformed into an analogic signal by the same circuit (CDA). Also in this case, the output signal of the differential amplifier (AD') is measured by an adjustable threshold discriminator, (DS') controlled by the panel control (R'). The signal of possible defect generating a rejecting operation is conveyed, together with that of (DS) to the general (OR). In particular, is sufficient only one of the two rejecting signals, to determine the rejecting of the banknote.

These two devices permit, by acting in pair, to provide a different severity in the control of the diffused defects, by the first device, rather than point defects, by the second device. It is also apparent that, in any case, jointly or separately, the defects are subjected to an evaluation severity which may be adjusted by the operator.

Furthermore, the master discrepancy signal, as produced by the differential amplifiers (AD, A') and discriminated in (DS, DS') is also sent to the circuits (CLK, CLK') which measure the time duration thereof, reported to extension on the sheet surface.

There is the possibility that discrepancy signals of low intensity would not be able of causing a generation of the rejecting signal by (DS, DS'); however these signals may be related to diffused defects which, due to this characteristic, even of low intensity, may be intolerable. Therefore, by presetting by (P) and (P') the maximum duration of the acceptable defect the system is rendered sensible alsc to the weak but extended defects.

The rejecting signals generated by (CLK, CLK') are conveyed, together with those of (DS, DS') to the general (OR).

The printing defect searching method thereinabove described permits to detect defects which are normally visible for the human eye and to satisfy in this way the normal needs.

As more sophisticated needs have to be met, such as those related to the point defects in order to detect point defects detectable in a difficult way, due to the very reduced size thereof, though in the presence of geometrically broad or large defects usually tolerated by the human eye, is used the circuit illustrated in Figure 5 which completes the thereinabove described system. It takes up the signals from the photometric heads (4) and compares said signals as coupled in the following way. Each photometric head (4) examines a determined path on the sheet wrapped on the transport cylinder. Each column of banknotes, as illustrated in Figure 3, is examined by a plurality of heads (4). By means of the electronic device thereinabove described are compared the signals sent by pairs of photometric heads located in a homologous position in banknote adjacent columns. For example the head examining the left-most portion of the first column and the head examining the left most portion of the second column. These two heads (which in Figure 5 are the head 4 and the head 4') examine identical portions of banknotes of different columns. Therefore they at the output thereof have to provide a like or equal signal. A difference between the two signals corresponds to a defect of one of the two banknotes. The two signals are compared one against the other by means of the two circuits illustrated in Figure 5. Through the first circuit, on the top, the two signals are sent to the differential amplifier AD therefrom exits the difference signal indicating the presence of a possible defect on one of the two banknotes. The signal is discriminated by the discriminator DS the threshold thereof is adjusted by means the presetting device R.

In order to provide a further classification criterion about the importance of the detected defect, is measured the time duration over which it is detected by means of the clock device CLK in which the time of acceptability (or not) of the defect is reset by the circuit P. In the case in which the defect causes a reflection difference having a sufficiently high value and of a duration exceeding a given duration is generated a rejecting signal which is sent or supplied to the general OR, this latter being the same general OR thereto arrive the rejecting signals of Figure 4.

In the case in which one desires to give a greater importance to point type defects, are analyzed the signals of the two heads, in the way thereinabove indicated, but after having differentiated the time diagram thereof.

This is obtained by means of a differentiation circuit (D). The output signal therefrom is then processed as the signal which has been analyzed without being differentiated by circuits identical to those herein described but separated and indicated in the drawing by the same references and the asterisks. Also in this case the possible rejecting signal is supplied to the general (OR).

This devices for analyzing the signal, as it should be apparent from the description, do not use the stored image of the electronic master and permit to detect the presence of very small defects even in the presence of strong differences, however tolerable, between the actual sheet and master memory or store. The described device is complementary to that using the master and described referring to Figure 4 and it is not able to operate by itself since it is insensible to defects even very great, such as the complete failing of the printing which may not be detected as a difference between two photometric channels.

Both in the case of the error searching device described referring to Figure 4 and in the case of the error searching device illustrated in Figure 5 the signal from the photometric heads 4 is analyzed either directly or by means of a preliminary differentiation.

In order to obtain a still more sensible selection, that same signal may be analysed after the treating thereof by means of techniques of transformation in a frequency spectrum by means of the known methods of the high speed Fourier transfrom or fast Fourier transform FFT. This signal may be also subsequently filtered out by the digital filtering technique to further enhance

certain types of defects and reduce other types of defects depending on the processed material type.

In order to achieve this object, it is sufficient to replace the conventional differentiating circuits indicated at (D) in Figures 4 and 5 by the suitable circuits for real time obtaining the (FFT) and for carrying out the digital filtering.

In order to obtain the detecting of point spots the system uses the device thereinbelow described.

The machine according to the present invention comprises, obviously, a second conveying cylinder (5), identical to the aforesaid cylinder (3) for examining the verso of the sheets by the photometric head (6), equal to the photometric head (4) and effective to use circuits for analyzing and comparing the signal identical to the thereinabove described circuits.

Downwardly from the aforesaid photometric head (6) is located an obliterating device (7), formed by a printing machine provided with hammers inked by magnetic or fluorescent ink of known type, each facing a column of banknotes present in the sheet.

If, upon an examination carried out on the two cylinders (3, 5) has not been detected the presence of any defective banknotes, no printing element is operated. On the contrary, the encoder (27) rigid with the cylinders, signals the passage time of the defective banknote and, correspondingly, the hammer is projected towards this latter. Said defective banknote, therefore, is marked in a way which is highly visible and may be detected by means of the conventional detectors usually located on the machine for preparing banknote packages.

The instant machine comprises, furthermore, heads (8) for controlling the filigree, which heads carry out said control by transparency observing the sheets. The aforesaid heads, by means of the encoder signals, varify the existence of the transparency variations due to the correct drawing of the filigree. Those same heads, furthermore, control that the position of said signal on the single banknotes be in perfect registering with the printing.

The thus controlled and possibly discriminated sheets are then conveyed to a collecting assembly formed by a series of boxes (9, 10, 11) and associated to an output box selection electronic system.

If no presetting is carried out by the operator, then the sheets are collected in the box (9), if they present even one only defective banknote, while they are collected in the box (11) if they are perfect.

If, on the contrary, the operator carries out a setting operation for a number (N) of defective banknotes (said number N being obviously less than the number of the banknotes present on the sheet), then the control electronic for the system operations compares the rejected banknote number with the set number. If the number of the rejected banknotes is zero, it sends the sheet to the box (11) of the perfect sheets. If the number of the rejected banknotes present on the sheet is included between (1) and (N), then the sheet is sent to the box (10) of the reusable sheets. Finally, if the number of the defective banknotes present on the sheet is greater than the N value then the sheet is sent or delivered to the box (9) of the sheets to be destroyed.

The principal block of the electronic circuitry (12) contains all of the electronic devices which, due to encumbering or machine noise insulating reasons it is not strictly indispensable to locate in the machine main body.

Claims

1. A machine for completely and fully automatically controlling the quality on freshly printed banknotes and other types of value documents, characterized in that it substantially comprises a control head pair said heads being effective to high speed examine the single sheets, respectively on the recto and verso, by means of the scanning of the overall front and rear surfaces of the sheet along a great number of paths within each thereof the analogic reflection signal, picked up through suitable photometric devices, is digitally fed and compared with the recording of the analogue signal as obtained by a sample sheet, in such a way that where are detected possible defects is generated a rejecting signal effective to permit to a printing device (downwardly of the system) to print or impress a recognizing mark on the defective banknote at the passage thereof, by acting as a consequence of the store of the device, while subsequently the sheets to be controlled pass through further devices effective to verify the abutting or registering presence of the filigrees, being conveyed within suitable differentiated boxes.

2. A machine as claimed in claim 1, wherein it comprises a loading magazine therefrom the sheets to be controlled are started, by means of a feeder for printing machines provided with a pliers and square mechanism for the abutting or registering along a path supplying, sequentially, a cylinder pair for conveying said sheets under corresponding quality inspection heads and, subsequently, a third cylinder for transporting the sheets under an obliterating device.

3. A machine as claimed in claim 2, wherein said cylinders for conveying the sheets under the inspection heads are provided with a gripping device, formed by pliers effective to assure a perfect longitudinal registering or abutting of the sheet on the cylinder and preserving a perfect transversal registering, provided by the side square located on said starting path, of conventional type, in the printing machine art.

4. Machine as claimed in claim 2 or 3, wherein the aforesaid cylinders are hollow in the inside thereof and subdivided in spaces or gaps by a plurality of radial sectors communicating to the outside, while the cylinder surface is suitably perforated by means of corresponding holes as radially formed at the two end portions of said

cylinders; said radial holes extending under sucking boxes and being effective to cause a sucking action firstly on the side of the sheets and then at the center.

5. A machine as claimed in claim 4, wherein the aforesaid radial or axial holes, extending under the aforesaid sucking boxes are effective to communicate with corresponding vacuum ducts, effective to provide the sucking action at the center of the cylinder spaces in such a way as to provide a drawing or attraction effect firstly at the center of the sheets and then on the sides thereof, the use of said sucking action, alternatively to claim 4, being a consequence of the substance of the paper.

6. A machine as claimed in any one of claims 2 to 5, wherein the portion to be controlled of the sheets transported by the aforesaid cylinders is illuminated by means of lamps emitting white sun light for obtaining an optimal displaying of the colours the reflex thereof being picked up by a high speed photometric module, formed by a light collimator scanning a narrow strip within the column extending in the front of said module, said reflected beam being transformed into an electric signal by means of photodiodes, or phototransistors, or arrays thereof, or photomultipliers, characterized, furthermore, by the capacity of detecting small diffused variations of the saturation and chroma and simultaneously point intensity variations having a size lesser than 1 mm^2.

7. A machine, as claimed in claim 6, wherein the scanning slot which, normally, has an elongated rectangular shape perpendicular to the sheet advancing direction, is able of having also different shapes, in this case said slot moving in a transversal direction with respect to the sheet and scanning said sheet by means of alternating scanning operations, the related movement of said slot being also effective to be provided both by a flying light spot, alternatively illuminating the sheet at different zones and the reflected light thereof is picked up or collected by a fixed sensor, and by a fixed light spot or beam evenly illuminating the overall surface, in this case the scanning being carried out by sequentially actuating the optical detectors grouped in an array having a high linear packaging density (array of photosensibles diodes).

8. A machine as claimed in claim 7, wherein the output signal of said sensors is sent to a c.c. current signal suitable amplifier and processed in such a way as to provide a voltage versus time diagram, to said diagram being associated, by means of an encoder rigid with the rotation axis of the transport cylinders, timing pulses effective to transform the diagram with a time abscissa into a diagram with a metric abscissa, at said timing pulses, in particular, the signal being coded into a number measuring the volt or volt fraction height thereof.

9. A machine as claimed in claim 8, wherein it comprises an electronic device effective to carry out a comparing between the aforesaid diagram and an ideal diagram, preliminarily stored in an integrated circuit high speed digital store or memory in such a way that, as the two diagrams are not identical, said electronic device carries out a reading operation at the progressive peak of the aforesaid timing pulses at which has been detected the discrepancy between said diagrams, holding in said store said datum in order to provide a subsequent obliterating signal.

10. A machine as claimed in claim 8 or 9, wherein it comprises a high speed digital calculating device, effective to load in said store the data related to the average of the reflection characteristics of the several sheets devoid of defects, as subsequently passed under the aforesaid inspection heads, by elaborating or providing an average or mean master of the sheet.

11. A machine, as claimed in any one of the preceding claims, wherein it comprises detectors effective to detect the position of the head of the printed banknote columns, in order to synchronize the extraction of the masterized photometric signal with the occurring of the head signal.

12. A machine, as claimed in any one of the preceding claims, wherein said machine is set for selecting said sheets according to a different severity degree, both with respect to point defects and with respect to diffused defects, depending on the needs, by means of a processing of the signal of the photometric heads, said signal being divided along two paths before being compared with the signal from the master store, along the shortest paths said signal being directly conveyed to a differential amplifier and entering through one of the two inputs thereof while, through the other input is entered the signal taken up, in a numeric form, from the master digital store or memory and subsequently transformed into a analogic signal, by means of a control device located on the operator control panel, the rejecting threshold, as measured by a suitable discriminator, being effective to be adjusted thereby rendering the control more or less sensible to the sheet local intensity differences with respect to the master, while, if the measured difference is greater than the predetermined threshold value, is provided a rejecting signal which is supplied to a circuit slaved to an obliterating device.

13. A machine, as claimed in claim 12, wherein in said machine, the signal from said photometric head is futhermore sent to a differentiating circuit effective to transform said signal, by enhancing the sharp variations thereof, said differentiating circuit sending said signal to a second differential amplifier receiving, from one hand, the differentiated signal and, from the other hand, the master signal transformed into an analogic signal, the output signal of said differential amplifier being measured by an adjustable threshold discrimator thereon it is possible to act by means of a panel control.

14. A machine, as claimed in claim 13, wherein in said machine, the discrepancy master signal, as produced by the aforesaid differential

amplifiers and suitable discriminated, is also sent to circuits effective to measure the time duration thereof, the maximum time duration of the defect being effective to be preliminarily adjusted by means of panel controls.

15. A machine as claimed in any one of the preceding claims including the possibility of comparing the reflection signal from head pairs scanning homologous adjacent banknotes columns, in such a way as to detect very small reflection differences said possibility completing the master system in order to permit the detection of point defects having a smaller size than that of the defects detected by the master system which preserves in the contents thereof its sensibility for the diffused errors.

16. A machine, as claimed in claim 15, including the possibility of carrying out the comparing by means of head pairs by analysing the signal from the two heads by a comparing operation, by analogically comparing the intensity of the two signals, by measuring the time duration of the persisting of the difference and permitting the adjusting both of the time duration in which the reflection difference is tolerable and the permissible variation amount.

17. A machine, as claimed in claim 15 or 16, including the possibility of carrying out the comparing by means of head pairs by analysing the signal from the two heads upon having suitably modified said signal by means of the differentiation technique of the high speed Fourier transform (FFT) and of digital filtering.

18. A machine, as claimed in claim 16, wherein downwardly from the aforesaid photometric heads is located an obliterating device, formed by a printing machine provided with inking bars using magnetic or fluorescent ink, each said inking bar facing to a column of banknotes present on the sheet under examination.

19. A machine, as claimed in claim 16, 17 or 18, wherein it comprises heads for controlling the filigree, operating by transparency and which, through the encoder signals, verify the existing of transparency variations due to the correct filigree designs, said heads being furthermore effective to control that the position of the aforesaid signals on the single banknotes be in perfect registering with the printing.

20. A machine, as claimed in any one of the preceding claims, wherein it comprises a system for the collection in three different boxes of the examined sheets, in said boxes being respectively collected only perfect sheets, only sheets having a number of defective banknotes greater than a predetermined threshold, and only sheets having a defective banknote number greater than zero but lesser than or equal to said predetermined threshold.

21. A machine, as claimed in any one of the preceding claims, wherein it comprises a device effective to display, at the passing of each sheet, the map of the defective banknote locations, both on the recto and on the verso, in said map, furthermore, being possible to distinguish, by means of a light code, the reason of the banknote reject.

22. Machine as claimed in claim 21, wherein said machines comprises sheet counting devices, at the input of the system and at the output of the several boxes, effective to provide a complete counting of all of the processed sheets, with the possibility of obtaining printed data.

23. Machine according to the preceding claims, characterized in that said machine carries out the quality control on value paper sheets, said paper being also of the filegree type, not yet printed, in order to obtain the identification of defects which might discourage the use of defective sheets for the printing.

24. Machine as claimed in any one of the preceding claims wherein said machine may be used for controlling the output tape or band from a bobbin type of printing machine.

25. Machine as claimed in claim 1, substantially as described herein with reference to the accompanying drawings.

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